

Modified Enlarged 18pt

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Tuesday 12 January 2021 – Afternoon

Level 3 Cambridge Technical in Applied Science

05847/05848/05849/05874/05879

Unit 1: Science fundamentals

Time allowed: 2 hours plus your additional time allowance

You must have:

the Insert for Questions 1 and 3

the Data Sheet

a ruler (cm/mm)

copy of the Periodic Table

You can use:

a scientific or graphical calculator

an HB pencil

Please write clearly in black ink.

**Centre
number**

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**Candidate
number**

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First name(s) _____

Last name _____

**Date of
birth**

D	D	M	M	Y	Y	Y	Y
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READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

INFORMATION

The total mark for this paper is 90.

The marks for each question are shown in brackets [].

The Periodic Table is supplied separately.

ADVICE

Read each question carefully before you start your answer.

Answer ALL the questions.

- 1 Elements can be identified by their atomic structure.**

Please refer to TABLE 1.1 in the Insert.

TABLE 1.1 shows the atomic structure of some elements, V, W, X and Y.

The letters V, W, X and Y are not the chemical symbols of the elements.

- (a) (i) Complete TABLE 1.1. [4]**

- (ii) Which TWO elements, V, W, X or Y are in the same Group of the Periodic Table?**

_____ and _____ [1]

- (iii) Use the information in TABLE 1.1 and the Periodic Table to deduce the chemical symbols of W and Y.**

W _____

Y _____

[1]

- (iv) What is the formula of the compound formed by elements W and Y?**

_____ [1]

- (v) State the type of bonding between W and Y, and the charges on their ions by completing the sentences using the words below.

You may use each word once, more than once, or not at all.

attraction

ionic

negative

positive

sharing

The type of bonding between W and Y is

_____.

In the compound that is formed, W is a

_____ ion and

Y is a _____ ion.

[2]

- (b) (i) Use nuclear notation to indicate the symbol of X, and its atomic number and mass number. Use the space below. [2]

- (ii) The nucleus of Y has more protons and neutrons than the nucleus of V.

Compare the strength of the attractive and repulsive forces within the nuclei of Y and V.

Explain why both nuclei are stable.

2 Carbon compounds containing chlorine have many uses, but they are also known to cause problems for the environment.

(a) Chlorofluorocarbons (CFCs) in the upper atmosphere can destroy the ozone (O₃) layer.

The first two reaction steps in the breakdown of O₃ are outlined in TABLE 2.1.

TABLE 2.1

Step	Reaction
1	$\text{CF}_3\text{Cl} \rightarrow \text{CF}_3 + \text{Cl}$
2	$\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$

(i) STEP 1 and STEP 2 involve free radicals.

Identify THREE FORMULAE in TABLE 2.2 that are free radicals. [3]

Tick (✓) THREE boxes.

TABLE 2.2

Formula	Free radical
CF_3Cl	
CF_3	
Cl	
O_3	
ClO	
O_2	

- (ii) Ultraviolet radiation from the Sun is needed to start STEP 1 in TABLE 2.1.

Suggest how ultraviolet radiation can increase the rate of reaction in STEP 1.

[2]

- (b) Chloroethene is a useful organic compound and has the formula $\text{CHCl}=\text{CH}_2$.

Chloroethene is made from ethane in two reaction steps.



- (i) Identify the type of reaction shown in STEP 1. [1]

Tick (✓) ONE box.

Addition

☐

Substitution

☐

Oxidation

☐

Reduction

☐

(ii) $\text{CH}_2\text{C}/\text{CH}_2\text{C}/$ has a structural isomer.

Draw the structural formula for the isomer of $\text{CH}_2\text{C}/\text{CH}_2\text{C}/$. Use the space below. [1]

(iii) $\text{CH}_2\text{C}/\text{CH}_2\text{C}/$ and $\text{CHC}/ = \text{CH}_2$ do not have geometrical isomers.

Give ONE reason why each molecule does NOT have geometrical isomers.

$\text{CH}_2\text{C}/\text{CH}_2\text{C}/$ _____

$\text{CHC}/ = \text{CH}_2$ _____

_____ [2]

- (c) Polyvinyl chloride is a polymer that can be made by the addition of many monomers of $\text{CHCl} = \text{CH}_2$.

- (i) What is the empirical formula of polyvinyl chloride? [1]

Tick (✓) ONE box.

CHCl

☐

CH_2Cl

☐

$\text{C}_2\text{H}_2\text{Cl}$

☐

$\text{C}_2\text{H}_3\text{Cl}$

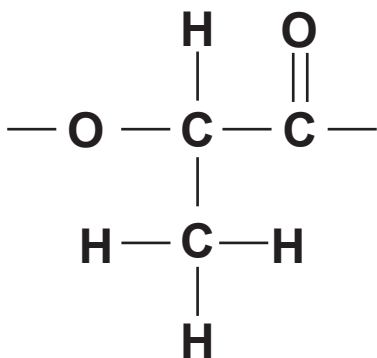
☐

- (ii) Draw a section of polyvinyl chloride which contains **THREE** repeat units.
Use the space below. [1]

- (iii) Polylactate is a different type of polymer compared to polyvinyl chloride.

The structural formula for the repeat unit of polylactate is shown in FIG. 2.1.

FIG. 2.1



Explain how the monomer and the polymerisation reaction that forms polylactate are DIFFERENT to those of polyvinyl chloride.

Difference in monomers _____

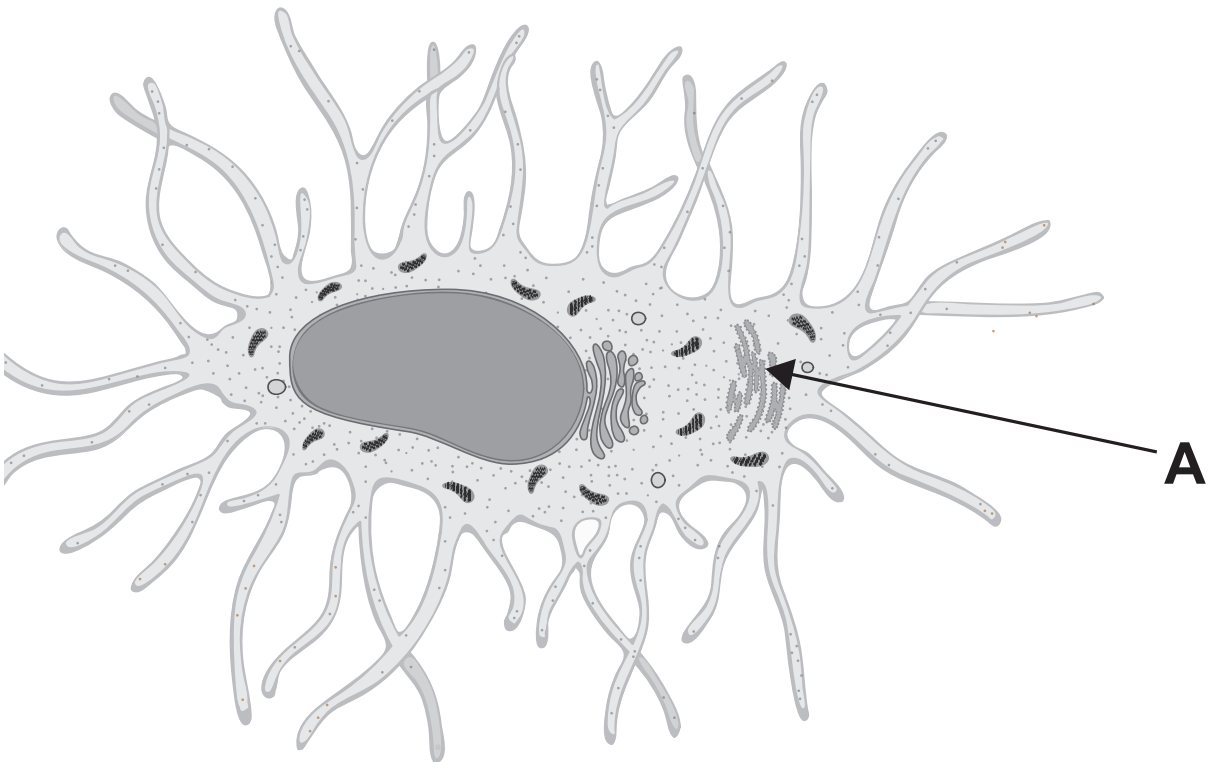
Difference in polymerisation reactions _____

3 Bone is a type of tissue found in the human body.

(a) An osteocyte is a specialised cell which is found in bone tissue.

FIG. 3.1 shows a diagram of an osteocyte.

FIG. 3.1



(i) Give the name of the organelle labelled A in FIG. 3.1.

[1]

- (ii) Organelle A can either appear as rough or smooth when observed on an electron micrograph.

Complete the following sentences.

You may use each word once, more than once, or not at all.

carbohydrate	chloroplasts
DNA	lipid
mitochondria	protein
RNA	ribosomes

The rough type of organelle A has

_____ attached.

This means that the rough type is involved in

_____ synthesis.

However, the smooth type of organelle A is the site of

_____ and

_____ synthesis.

[3]

(b) A key function of bone tissue is mineral ion storage.

(i) Which mineral ion is stored and used to form the matrix in bone tissue?

Put a ring around the correct answer. [1]

Ca^{2+}

K^{+}

Na^{+}

Ni^{2+}

(ii) Osteoporosis is a condition that affects bones.

The images in FIG. 3.2 show normal bone and bone with osteoporosis.

FIG. 3.2

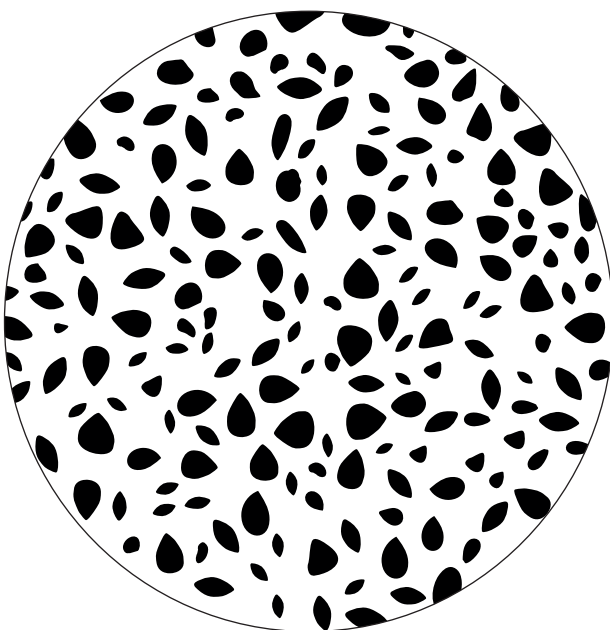
Key



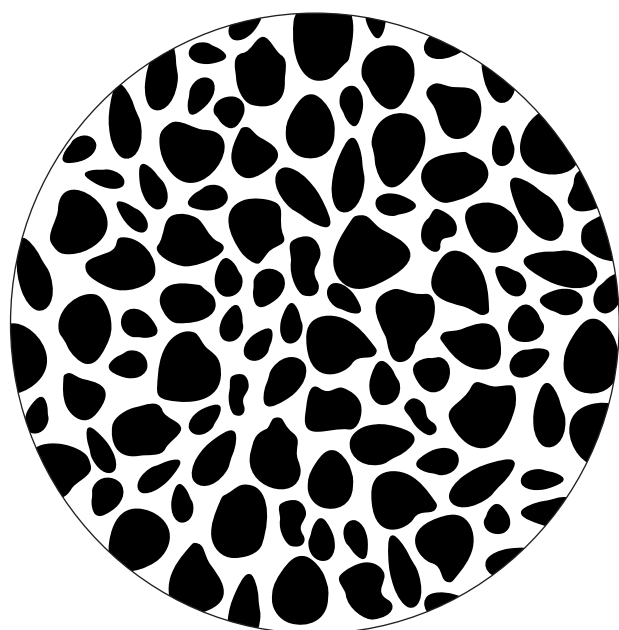
= bone matrix



= pores or gaps in bone matrix



Normal bone



Bone with
osteoporosis

Use FIG. 3.2 to suggest the link between osteoporosis and the mineral ion identified in (b)(i), and the effect of osteoporosis on bone function.

Link _____

Effect _____

[3]

- (c) Magnesium is another mineral ion needed for healthy bones.

It can be taken into the body via magnesium oxide supplements or in foods with a high amount of magnesium.

Please refer to TABLE 3.1 in the Insert.

TABLE 3.1 shows some foods and the amount of magnesium that they contain.

- (i) The recommended daily amount of magnesium is 320 mg for women.

A woman eats four 100g portions of one of the foods in TABLE 3.1.

Using the information in TABLE 3.1, identify which food she would need to eat to meet her recommended daily amount of magnesium.

Food = _____ [1]

- (ii) The recommended daily amount of magnesium is 420 mg for men.

A man eats a 50 g portion of almonds.

Using the information in TABLE 3.1, calculate how much more magnesium a man would need to reach his recommended daily amount.

Amount of magnesium needed = _____ mg [2]

- (d) Some enzymes need metal ions, such as magnesium, so that they can function.

What is the role of metal ions in enzyme function?

[1]

4 Carboxylic acids are a family of organic compounds with the functional group –COOH.

(a) Butanoic acid (C₄H₈O₂) has a hydrocarbon chain and a –COOH group.

Draw the structural formula for butanoic acid, showing all the bonds. Use the space below. [1]

(b) Ethanoic acid, CH₃COOH, reacts with sodium hydroxide to form a salt and water.

Complete the equation for this reaction.



[2]

- (c) Ethanoic acid can be reduced to other organic compounds.



What type of organic compound is formed? [1]

Tick (✓) ONE box.

Alcohol

☐

Aldehyde

☐

Alkyne

☐

Ketone

☐

- (d) Fatty acids are carboxylic acids with a long hydrocarbon chain.

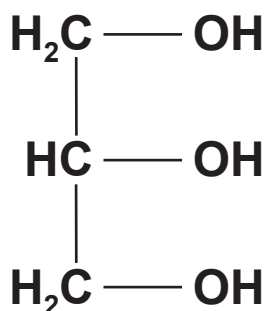
Fatty acids are found in the human body.

Fatty acids react with glycerol to form a lipid.

A lipid contains one or more ester groups.

FIG. 4.1

Glycerol



Fatty acid



- (i) Draw the structural formula of a lipid that forms from the reaction of glycerol and ONE molecule of the fatty acid shown in FIG. 4.1.

Clearly show the structure of the ester group. Use the space below. [2]

- (ii) The lipid drawn in (d)(i) is also known as a monoglyceride.

State how a triglyceride is different from a monoglyceride.

[1]

- (iii) State what is released when lipids are broken down to reform glycerol and fatty acids.

[1]

- (iv) Explain the importance of lipids for nerve transmission in the human body.**

[2]

- (v) Give ONE other function of lipids in the human body.**

[1]

- (e) Sundip is a science student. She is studying the effect of temperature on the rate of reaction between a fatty acid and glycerol.**

She chooses two temperatures: Temperature 1 and Temperature 2.

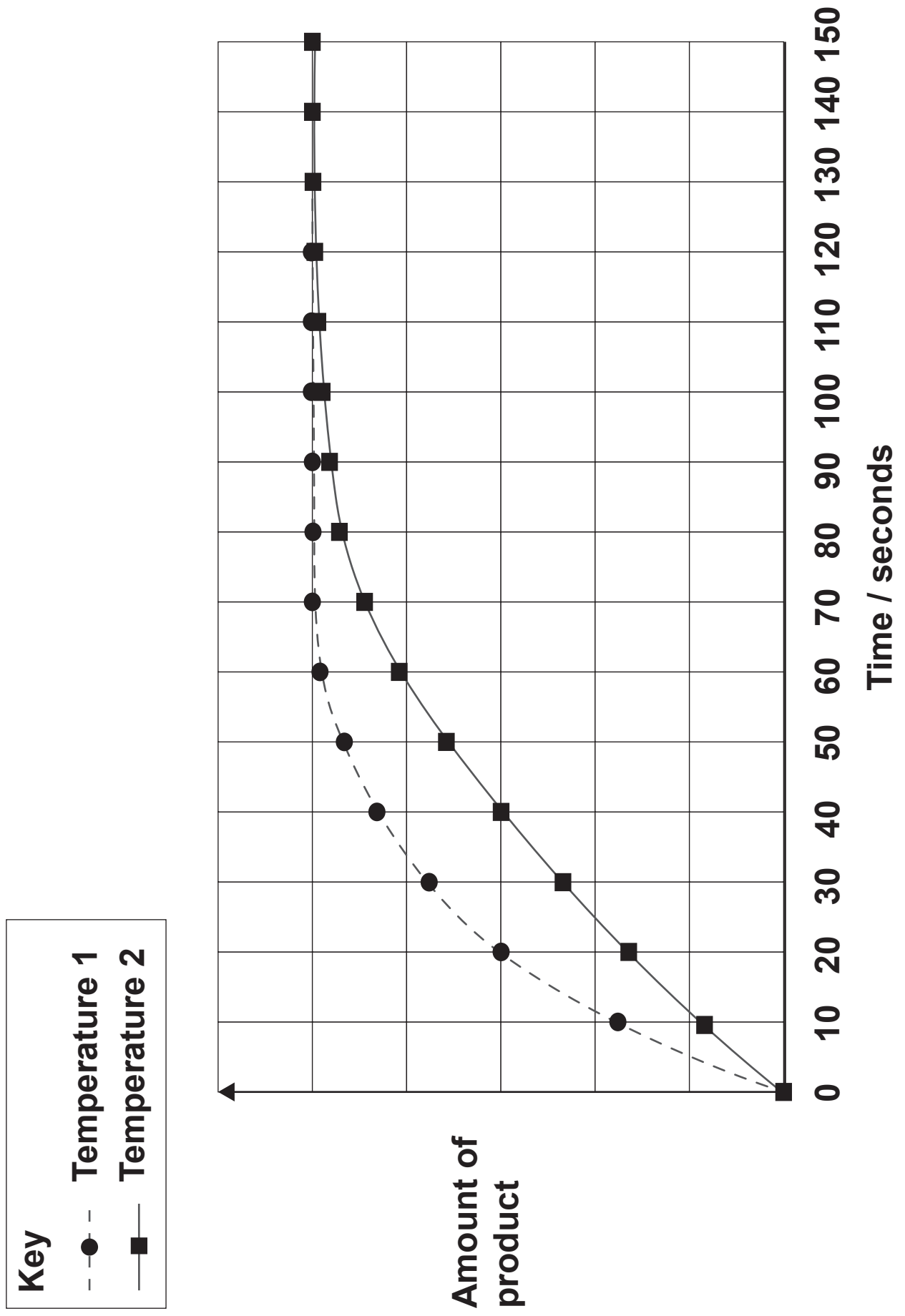
She plots a graph of her results for both temperatures.

The graph is shown in FIG. 4.2 opposite.

- (i) Use the graph to deduce which temperature is higher, giving reasons for your answer.**

[2]

FIG. 4.2



(ii) Explain the effect of temperature on the rate of reaction.

[2]

5 Phosphate is a component of phospholipids DNA and RNA.

- (a) Phospholipids are an essential part of the membranes found around organelles in cells, such as the nuclear envelope.**

Complete the following sentences.

Use the words from the list. You may use each word once, more than once, or not at all.

double	eukaryotic
flexible	photosynthetic
porous	prokaryotic
single	triple
thin	

The nuclear envelope surrounds the nucleus and consists of a _____ membrane.

The membrane is _____ to allow protein molecules to be transported across the nuclear envelope.

The presence of a nuclear envelope indicates that the type of cell is _____ .

- (b) Name ONE membrane-bound organelle found in cells, other than the nucleus.**

[1]

- (c) DNA and RNA are nucleic acids.**

They are made of nucleotides.

Each nucleotide contains a phosphate, a sugar and a base.

- (i) Identify the correct phosphate link between nucleotides. [1]**

Tick (✓) ONE box.

Base – Phosphate – Base

☐

Base – Phosphate – Sugar

☐

Sugar – Phosphate – Base

☐

Sugar – Phosphate – Sugar

☐

- (ii) The bases found in some nucleotides can pair with other bases.

Draw a line to link BASE 1 with its complementary BASE 2. [2]

BASE 1

BASE 2

Guanine

Adenine

Cytosine

Thymine

Guanine

Thymine

- (iii) Although the phosphate group is always the same, the sugars and bases are different in DNA compared to RNA.

Complete the table to compare the sugars and bases found in DNA and RNA. [4]

Feature	DNA	RNA
Type of sugar found		
Four bases found		

6 Copper and its ions have uses in metallic structures such as bronze, and in biological molecules such as haemocyanin.

Bronze is an alloy of copper and tin, and is used to make coins and statues.

Haemocyanin is a protein found in the bodies of invertebrates such as insects. Its function is to carry oxygen in a similar way to haemoglobin in vertebrates such as humans.

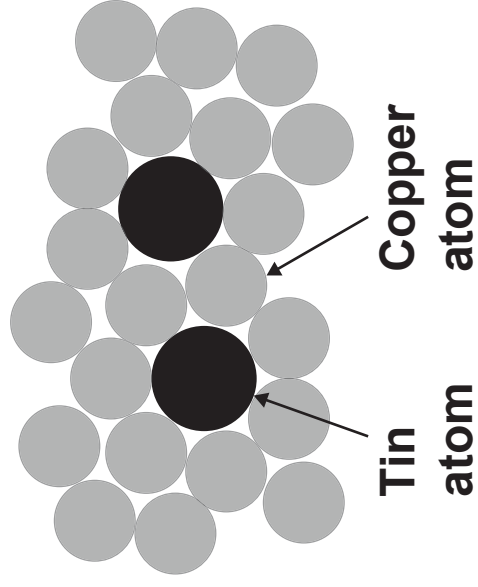
The structure of bronze and the oxygenated form of haemocyanin are shown in FIG. 6.1 opposite.

Describe the structures of bronze and haemocyanin as shown in FIG. 6.1 and how these determine their properties and function or uses.

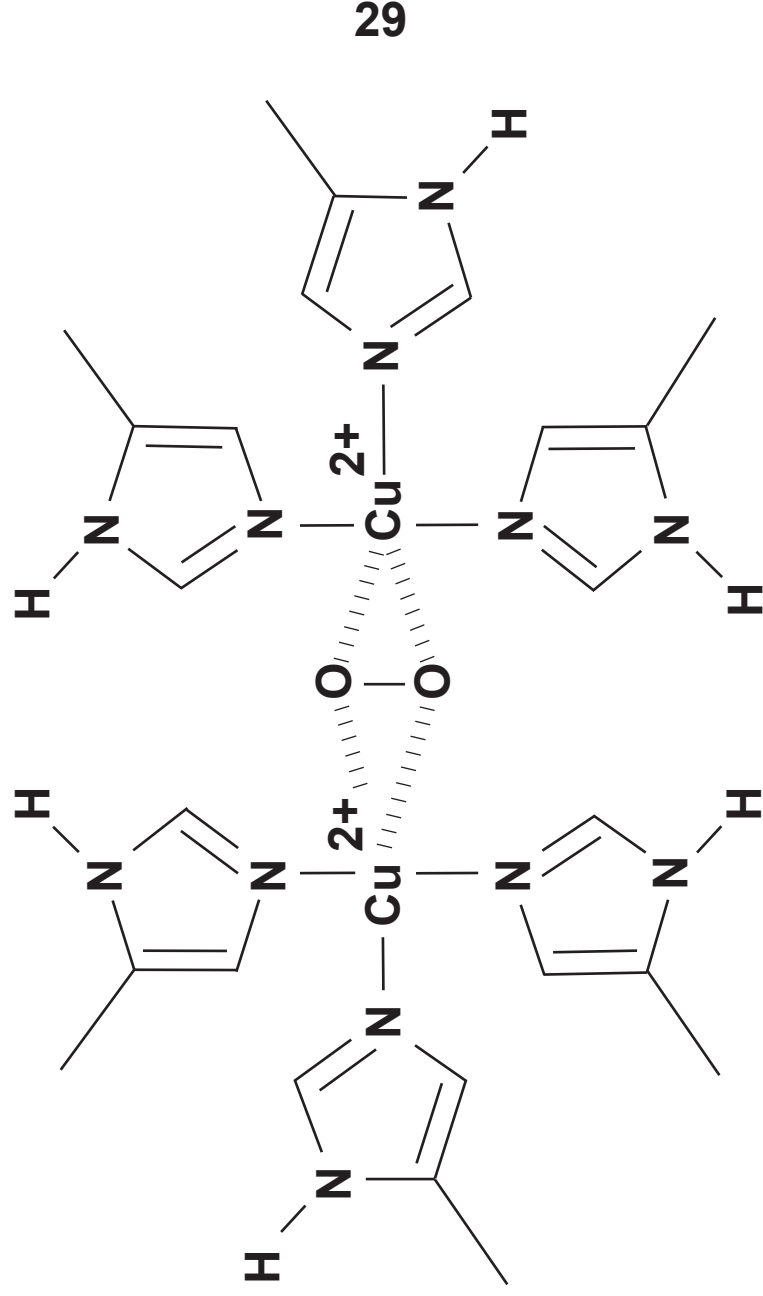
[6]

FIG. 6.1

Bronze



Haemocyanin (oxygenated form)



7 Different metals have different physical properties such as strength, hardness and density.

(a) The Vickers Hardness Test is used to determine the hardness of materials such as metals.

In this test, a diamond pyramid is pressed into the surface of a sample of the material.

FIG. 7.1 opposite shows the laboratory instrument that is used, and a diagram of the test.

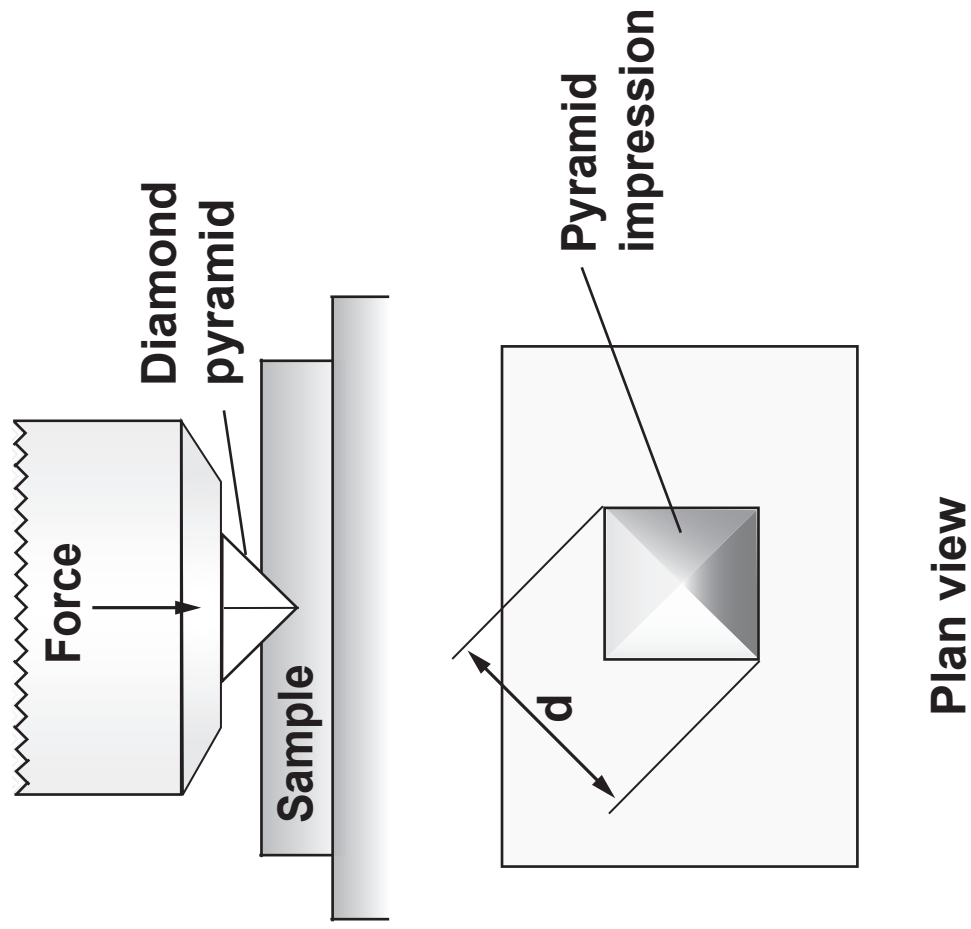
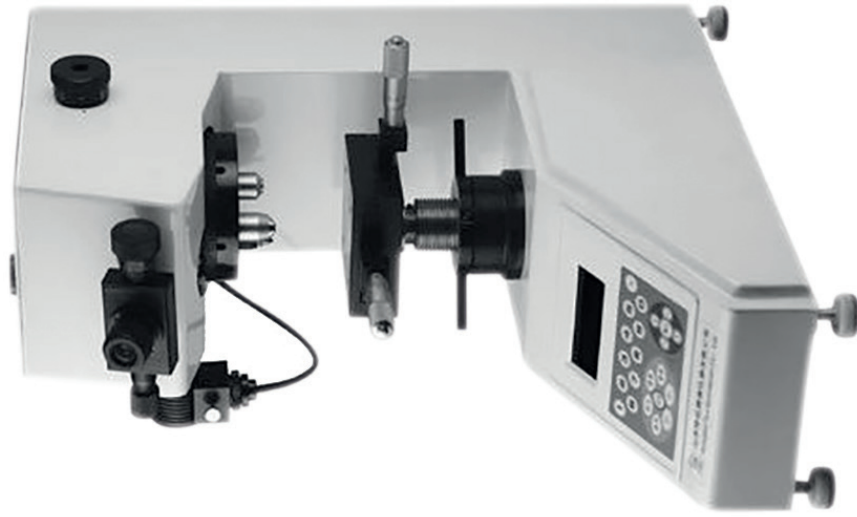
(i) Use the information in FIG. 7.1 to suggest how the Vickers Hardness Test is used to compare the hardness of different metals.

[3]

(ii) Suggest why a diamond pyramid is used in the machine.

[1]

FIG. 7.1



- (b) An important property of a metal is its strength to weight ratio.

This is a number which can be calculated by dividing the strength (in MPa) of the metal by its density in g cm^{-3} .

TABLE 7.1 shows the strength and density of four metal alloys.

- (i) Use the information to calculate the strength to weight ratio for each alloy.

Write down the values in the table.

Give your answers to 3 significant figures. [2]

TABLE 7.1

Metal	Strength / MPa	Density / g cm^{-3}	Strength to weight ratio
Aluminium alloy	310	2.70	
Stainless steel	505	8.00	
Titanium alloy	1250	4.81	
Low-carbon steel	365	7.87	

- (ii) Which metal alloy in TABLE 7.1 would be most suitable for constructing a racing bike?

Tick (✓) ONE box.

Aluminium

☐

Stainless steel

☐

Titanium

☐

Low-carbon steel

☐

Explain why you have chosen this metal alloy.

[1]

- (iii) Suggest TWO other factors which you would need to consider when selecting the best material for a racing bike.

1

2

[2]

- 8 The potential difference across a resistor X is 5.0 V.
The current in the resistor is 0.5 A.

(a) Calculate the resistance R_x of resistor X.

Use the equation:

potential difference = current \times resistance

$$R_x = \underline{\hspace{10cm}} \Omega [2]$$

(b) Resistor Y is placed in series with resistor X.
The potential difference across both resistors
is 5.0 V.

The current in the resistors is 0.087 A.

Calculate the resistance R_y of resistor Y.

$$R_y = \underline{\hspace{10cm}} \Omega [2]$$

(c) Resistor X is now placed in parallel with
resistor Y.

Calculate the combined resistance R_t of X and
Y in parallel.

Use the equation: $\frac{1}{R_t} = \frac{1}{R_x} + \frac{1}{R_y}$

$$R_t = \underline{\hspace{10cm}} \Omega [2]$$

- (d) A lamp is placed in the circuit so that resistor X, resistor Y and the lamp are all in parallel.

The total current in the circuit is 0.75 A.

Show that the charge Q transferred through the lamp in one minute is about 8.6 C.

Use the space below. [3]

END OF QUESTION PAPER

[illegible]



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